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# RESANDING PROBLEMS AT ALBANY

## By G. E. Willcomb

The scrubbers or rapid filters at Albany were placed in operation October 29, 1908. These filters are identical in construction with the socalled American mechanical filter except that they are designed to operate without preliminary coagulation, and in consequence are filled with a coarser sand than is customary to use in a mechanical filter. No air agitation during washing is provided for, dependence being upon a high vertical rise of the wash water to break up and carry off the schmutzdecke. The underdrain system is simple and consists of brass ferrules projecting one inch above the filter floor and spaced 9 inches on centers. Arranged radially around the perimeter are eight staggered holes each of which is $\frac{5}{32}$ inch in diameter. Twelve inches of gravel graduated from 3 inches to $\frac{1}{8}$ inch sizes was placed over the sand valves and 14 inches of sand placed over this. The sand used was disintegrated shale dredged from the bed of the Hudson River. Its effective size was 0.38 mm. with a uniformity coefficient of 3.17. Its cost in place in the bed was $1 per cubic yard.

Results of experimentation carried on over a period of a year demonstrated that under the above conditions a rate of 80,000,000 gallons per acre per day could be maintained giving an efficiency of 60 per cent in bacterial reduction and an efficiency of 50 per cent in the removal of turbidity. The experiments also showed that under such conditions the slow sand filters could operate at a maximum rate of 6,000,000 gallons per acre per day, which was twice the rate attained under the old conditions using water which had received 14 hours plain subsidence. During the experiments difficulty was encountered in washing the sand layer, the top 6 inches becoming silted up to such an extent that the wash water would divide it into sections, which being of a higher specific gravity would sink to the bottom, and soon form an impervious zone from the gravel to the top, such that the wash water could not make its way through the mass and took the course of least resistance around it. A maximum vertical rise of 2 feet per minute failed to loosen up the sand, which resulted in the formation of springs over each sand valve, and ultimately decreased the bacterial efficiency in direct proportion as the resultant rate of filtration was increased through the restricted filter area. As a consequence, at the conclusion of the experiments it was realized that the sand in the actual filters would have to be ejected out of the beds and cleaned periodically.

The wisdom of employing a filter sand of such low effective size and with so high an uniformity coefficient was questioned at the time. To the writer its use was justified by the fact that it was the only cheap sand available at the time, and that by prolonged washing and scraping off of the fine sand brought to the top, an increase in the effective size would be attained, and as a consequence of prolonged washing the entire sand layer would be graded according to the hydraulic values of the separated sand grains, so that in the end, a graded filter medium would be worked up that would have filtering efficiency comparable to a sand medium of uniform sized grains from top to bottom.

The function of a filtering medium is to induce and maintain a schmutzdecke either of biological or chemical origin; all other functions are subordinate. Theoretically, a top layer 8 inches thick of 0.40 mm. sand ought to do as much useful work as 30 inches of uniform sand. If coagulation is employed and the coagulation is well executed, the top 8 inches will be as efficient in the removal of the residual hydrate as 30 inches of uniform sand. This fact is well illustrated by the conditions in the capital district about Albany, where there are four typical mechanical plants working under the same conditions as the Albany plant, yet all pass as much hydrate through the sand medium as does the latter plant. This serves to emphasize the fact that the phenomenon of the passage of hydrate through a filtering medium is a function of the degree of success of coagulation. Practically, the 8-inch layer does not work out as well as the uniform 30-inch medium. The efficiency of the wash is less and the tendency to ball and mound up is greater. In the case of the graduated sand, most of the silt and hydrate accumulated during the filter run is retained in the top 8 inches, consequently when the wash water is applied and the whole sand medium is in suspension and agitation, the tendency is for certain portions of the schmutzdecke layer to sink to a level of the fine gravel and become the nucleus of a ball or mound formation at that point. On the other hand, the tendency of a graduated layer to pass fine particles of sand through the sand valves is much less than with a uniform sand. The writer's experience with different mechanical plants has impressed him with the importance of this fact, and in the light of all things considered, it is his opinion that the increased initial cost of a uniform sand is not justified by the increased benefits derived.

As was stated at the beginning, the rapid filters were started October 29, 1908, with a 14-inch layer of sand of an effective size of 0.38 mm. After fourteen washings samples of sand were taken at different depths and table 1 gives the results of the mechanical analyses:

TABLE 1

| SECTION | EFFECTIVE SIZE | UNIFORMITY COEFFICIENT |
|---|---|---|
| *inches* | | |
| 0– 2 | 0.31 | 1.29 |
| 2– 4 | 0.31 | 1.51 |
| 4– 6 | 0.32 | 1.72 |
| 6– 8 | 0.32 | 1.88 |
| 8–10 | 0.38 | 2.00 |
| 10–12 | 0.39 | 2.56 |

After three weeks of operation 4 inches of fine sand were scraped off the top and the condition of the remaining sand is shown by the following table:

TABLE 2

| SECTION | EFFECTIVE SIZE | UNIFORMITY COEFFICIENT |
|---|---|---|
| *inches* | | |
| Top 4 | 0.45 | 1.78 |
| 4– 6 | 0.41 | 1.95 |
| 6– 8 | 0.46 | 2.15 |
| 8–10 | 0.53 | 2.45 |

From table 2 it is seen that a 10-inch layer of sand had been worked out of the 14-inch layer, the top 8 inches of which was fairly uniform and whose effective size seemed quite favorable. After using this sand for two months, it became rapidly silted up down to the gravel and had to be forked at frequent intervals as a supplement to the wash.

On June 22, 1909, eight months after the rapid filters were placed in operation, all of the Hudson River shale sand was ejected out of the beds and 30 inches of fresh shale sand from the same source put in its place. After a series of washings of the sand in place in the beds, and after several shallow scrapings had been removed, the resultant filter medium had the following composition:

TABLE 3

| SECTION | EFFECTIVE SIZE | UNIFORMITY COEFFICIENT |
|---|---|---|
| *inches* | | |
| 0– 6 | 0.42 | 1.91 |
| 6–12 | 0.45 | 2.10 |
| 12–18 | 0.50 | 2.24 |
| 18–24 | 0.51 | 2.94 |

The beds were operated with this sand until October 24, 1912, a period of three years and four months. During this time the sand was ejected, cleaned and replaced five times. On each ejection approximately 3 per cent of fine sand was lost and owing to the shaley character of the sand a large percentage of the grains became disintegrated by erosion and the top portion of the bed became finer in consequence and the tendency of the filter to ball up increased.

It was decided at this time to replace all the shale sand by silica sand and quotations were asked both for a graded and ungraded product. It was found that the cheapest graded sand that could be procured came from Cape May, New Jersey, and would cost $3.75 per ton f.o.b. Albany. Ungraded silica sand could be brought from Hemstead Harbor, Long Island, in scows for $0.95 per cubic yard. Owing to the great difference in price, it was decided to use this latter sand and work it over in the beds until it was suitable for the purpose. Samples taken from the scows showed the sand to have an effective size of 0.25 mm. with an uniformity coefficient of 2.28.

During October 1912, all the old shale sand was discarded and 100 cubic yards of the new silica sand placed in each bed. At different periods varying amounts of fine sand were scraped off the top and table 4 shows the results obtained by the scraping:

TABLE 4

| TIME ELAPSED SINCE FILLING BED | TIME ELAPSED SINCE LAST SCRAPING | AMOUNT SCRAPED | SUM TOTAL OF SCRAPINGS | RESULTANT EFFECTIVE SIZE OF ENTIRE SAND | RESULTANT UNIFORMITY COEFFICIENT |
|---|---|---|---|---|---|
| *days* | *days* | *inches* | *inches* | | |
| 14 | | 4 | 4 | 0.33 | 1.79 |
| 21 | 7 | 4 | 8 | 0.38 | 1.84 |
| 28 | 7 | 4 | 12 | 0.43 | 2.11 |
| 35 | 7 | 3 | 15 | 0.45 | 2.44 |

From table 4 it is seen that by prolonged washes and successive scrapings a sand of an effective size of 0.45 mm. was worked up out of the 0.25 mm. sand at the expense of rejecting 37½ per cent of the fine material. Experience has shown that had the time interval been longer and shallower scrapings made, this percentage loss would have been much less. It is seen that upon each successive scraping the uniformity coefficient increased in proportion. The higher the coefficient the more stratified did the total filtering medium become.

In order to demonstrate the degree of stratification of the filtering medium, mechanical analyses were made on different sections of the sand taken at different depths. Each determination represents the average obtained from several samples. In order to demonstrate the efficiency of the wash, six samples representing total sections of the bed from top to bottom of about 30 inches in depth, were analyzed for turbidity, organic nitrogen and oxygen consumed. The method employed was as follows: 100 grams of the sand were shaken in the engine with 100 cc. of water for one minute after which it was diluted to 1 liter. This liquid containing the schmutzdecke released from the sand by agitation was used as the base solution in making the determinations. In making the organic nitrogen determination, a modification of the Kjeldahl method was employed using phosphoric anhydride and direct nesslerization to facilitate matters. Corrections were made for moisture and the results expressed as parts per 10,000 grams of dry sand.

Table 5 gives the effective size of the different sections, the amounts of the different constituents stored in the total section of the filter medium, at six different points in the bed before and after the wash, and the percentage reduction of these constituents due to the wash.

## TABLE 5

| SECTION | EFFECTIVE SIZE | UNIFORMITY COEFFICIENT | EFFICIENCY OF WASHING | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Station | Before washing | | | After washing | | | Per cent reduction | | |
| | | | | Turbidity | Organic nitrogen | Oxygen consumed | Turbidity | Organic nitrogen | Oxygen consumed | Turbidity | Organic nitrogen | Oxygen consumed |
| *inches* | | | | | | | | | | | | |
| 0- 4 | 0.34 | 1.38 | A | 1400 | 1.00 | 9.8 | 975 | 0.68 | 6.8 | 30.4 | 32.0 | 30.6 |
| 4- 8 | 0.34 | 1.82 | B | 1400 | 0.96 | 8.5 | 875 | 0.64 | 7.0 | 37.4 | 33.4 | 17.7 |
| 8-12 | 0.62 | 1.77 | C | 1400 | 1.00 | 9.0 | 900 | 0.60 | 6.5 | 35.7 | 40.0 | 27.7 |
| 12-16 | 0.62 | 1.72 | D | 1500 | 0.80 | 10.6 | 925 | 0.36 | 7.0 | 38.3 | 54.9 | 34.0 |
| 16-20 | 0.64 | 1.72 | E | 1300 | 0.60 | 9.1 | 900 | 0.40 | 6.6 | 30.8 | 33.3 | 27.5 |
| 20-28 | 0.54 | 1.80 | F | 1750 | 0.80 | 9.9 | 1200 | 0.92 | 4.2 | 31.4 | | 57.6 |
| 28-36 | 0.60 | 1.70 | | | | | | | | | | |
| Average | ....... | ....... | ..... | 1460 | 0.86 | 9.5 | 965 | 0.60 | 6.4 | 33.9 | 32.2 | 32.6 |

## TABLE 6

| SECTION | BEFORE WASHING | | | | |
|---|---|---|---|---|---|
| | Effective size | Uniformity coefficient | Turbidity | Organic nitrogen | Oxygen consumed |
| *inches* | | | | | |
| A 0-10 | 0.35 | 2.08 | 1750 | 1.60 | 16.5 |
| B 0-10 | 0.33 | 2.24 | 1750 | 2.20 | 19.7 |
| C 0-10 | 0.38 | 1.95 | 1800 | 2.00 | 18.7 |
| D 0-10 | 0.37 | 1.67 | 1600 | 1.60 | 15.3 |
| Average | 0.36 | | 1725 | 1.90 | 17.5 |
| A 10-20 | 0.36 | 2.37 | 1750 | 1.44 | 15.7 |
| B 10-20 | 0.42 | 2.38 | 1400 | 0.96 | 15.5 |
| C 10-20 | 0.38 | 2.23 | 1500 | 1.04 | 14.1 |
| D 10-20 | 0.50 | 2.80 | 1200 | 0.88 | 9.0 |
| Average | 0.40 | | 1450 | 1.08 | 13.6 |
| A 20-30 | 0.54 | 2.77 | 1200 | 0.64 | 12.3 |
| B 20-30 | 0.49 | 3.26 | 1250 | 0.24 | 12.5 |
| C 20-30 | 0.40 | 3.00 | 1400 | 0.72 | 11.7 |
| D 20-30 | 0.52 | 3.07 | 1400 | 0.80 | 9.5 |
| Average | 0.49 | | 1300 | 0.60 | 14.0 |

| SECTION | AFTER WASHING | | |
|---|---|---|---|
| | Turbidity | Organic nitrogen | Oxygen consumed |
| *inc'es* | | | |
| Av. (A+B) 0-10 | 1600 | 1.80 | 17.3 |
| Av. (C+D) 0-10 | 1500 | 1.60 | 15.1 |
| Average | 1550 | 1.70 | 16.2 |
| Av. (A+B) 10-20 | 1400 | 0.96 | 14.5 |
| Av. (C+D) 10-20 | 1400 | 0.90 | 8.4 |
| Average | 1400 | 0.96 | 11.4 |
| Av. (A+B) 20-30 | 1350 | 0.24 | 13.7 |
| Av. (C+D) 20-30 | 1250 | 0.64 | 9.9 |
| Average | 1300 | 0.45 | 11.8 |
| AVERAGE PERCENTAGE REDUCTION | | | |
| 0-10 | 10.2 | 10.5 | 7.4 |
| 10-20 | 3.6 | 11.1 | 16.2 |
| 20-30 | | 25.1 | 15.7 |

It is seen from table 5 that, as might be expected, different portions of the bed store up more matter than others. A point of interest is the fact that the percentage reduction of all constituents is about the same. It must be noted that at the time these tests were made, the beds were being used as scrubbers and this accounts for the low percentage removal of stored turbidity, etc. It is therefore evident that the action of a scrubber is more or less accumulative; that the silt and organic matter, etc., are gradually stored up in the sand and eventually must be removed by ejection.

In order to ascertain the efficiency of the washing process at different depths of the bed, samples of 10 inch depth were taken at various portions of the filter. Table 6 gives the results obtained.

It will be observed that the efficiency of the wash in this instance is much less than that shown in the case of the preceding table. This may be explained by the fact that in the preceding instance the test was run during the winter while the latter was run in the summer time, when the organic growths were at their maximum development and their resistance to the agitation of the wash was greater. It is seen that as the effective size increases, the amount of matter stored up in the sand voids is correspondingly less. The efficiency of the wash in each stratum of the bed is practically the same.

In conclusion it may be said that out of a sand costing $0.95 a cubic yard, a sand of an effective size of 0.45 mm. was worked up by rejecting 37.5 per cent of the material by successive scrapings. Including the cartage this final sand cost $1.55 per cubic yard which was $2.83 a yard less than a uniform sand could be placed for. This cost does not take into account the pay of the laborers on the regular payroll, who did the work of washing the sand. Had extra labor been employed to do this work the cost of the final sand in place would have been increased by about $.15 per cubic yard.